A FILTER AND CHILLER FOR AN OPEN SEAWATER SYSTEM

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THE SEAWATER SYSTEM at the National Marine Fisheries Service's Atlantic Estuarine Fisheries Center in Beaufort, N.C., as described by Hettler, Lichtenheld, and Gordy (1971), has been modified to provide a more reliable filtration system and to furnish chilled water on a year-round basis. Because of the expanding interest in seawater systems for pollution research and marine aquaculture, two locally designed improvements, successfully operated for nearly a year, are described for the benefit of others considering building or changing seawater systems.

SEAWATER FILTER

After a year of service, the submerged filter units (Hettler et al.) were severely undercut by channel currents; the units toppled over and could not be operated in that position or salvaged. Even before this event, the filters were located in a position that made inspection and maintenance difficult. Subsequent expansion of research increased the demand for filtered water, especially for water with minimal suspended solid loads where constant flow rates through easily clogged valves was required.

The present filter system is diagramed in figure 1. It is constructed completely of nonmetallic materials—fiberglass tanks, polyvinylchloride (PVC) pipes and fittings, and crushed oystershells. The system is designed to operate either in parallel, to provide a large volume of once-through filtered water, or in series, to provide multiple filtration. Raw seawater flows by gravity from the primary storage reservoirs through a 7.6-centimeter pipe to the filter tanks. Each of the two 2,300-liter filter tanks is a fiberglass-reinforced flat-bottomed cylinder sitting on the ground outside the seawater laboratory. Seawater is admitted into the filter tanks by PVC float valves.

The filter medium in each tank consists of a 40-centimeter layer of "pullet-size" (about 5 millimeters in diameter) crushed oystershells. The surface area is 3.14 square meters. Beneath the oystershell is a manifold grid of slotted 5-centimeter PVC pipe. Kerfs were made in the manifold by cutting one-third through the pipe at 2-centimeter intervals with a circular crosscut saw. The manifold outlet leads to valves where the filtered water is either pumped directly to the temperature and salinity control reservoirs or recirculated to the other filter tank for additional passes through the filter medium, where both mechanical and biological filtration occurs, by a single 1/3-horsepower nitrile rubber centrifugal pump rated at 170 liters per minute at a 3-meter head.

The filters are cleaned by back-flushing each filter approximately every 2 months. Usually there is about 3 centimeters of silt, mud, and organic debris on top of the oystershells. Back-flushing is done by running a large volume of raw seawater through the slotted manifold up through the crushed oystershells. Compressed air is also bubbled vigorously up through the oystershells from numerous air outlets attached to the manifold piping. If necessary, packed oystershells and clumps of debris are broken up to a depth of about 25 centimeters with a clam rake. Back-flushing with air and water continues overnight. During cleaning, the other filter unit operates alone. No other maintenance is required.

The suspended solids in the raw seawater depend on the time of year, tide stage, wind, and rainfall runoff into the nearby estuary. Our normal range is between 12 and 23 milligrams per liter of material collected on a 0.45-micron membrane filter. Water passing through the filters operating in parallel contains 2–3 milligrams per liter of filterable material; after series filtration, less than 1 milligram per liter.

SEAWATER CHILLER

A seawater chiller was added to the open-flow seawater system (Hettler et al.) to provide cold water for experiments on the temperature tolerances and metabolic responses of estuarine organisms to low temperatures. The unit can chill seawater to the freezing point. Manually operated valves are used to blend chilled water with warmer, constant-temperature water to provide flowing seawater to each laboratory tank or aquarium at any temperature above 1°C.

To isolate the seawater from all metallic components, primary (Freon 12)[1] and secondary (ethylene glycol solution) refrigeration loops are necessary. The primary refrigerant chills the secondary refrigerant which then chills the seawater. The components of the complete chiller are diagramed in figure 2.

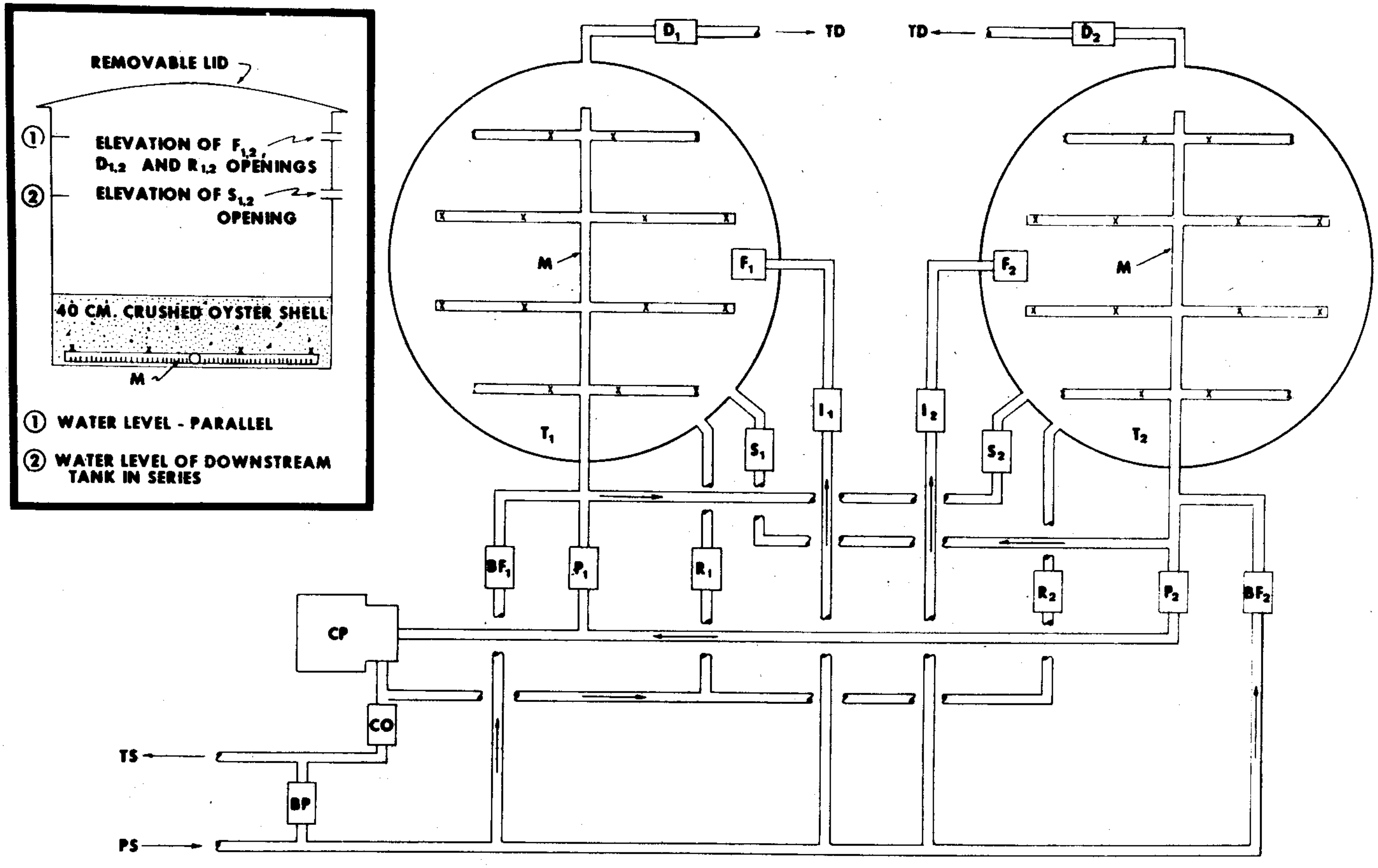
A 10-horsepower air-cooled refrigeration compressor/condenser delivers Freon 12 refrigerant to four 5-ton standard air-conditioning evaporating coils mounted in parallel. These copper and aluminum coils are placed vertically in a 600-liter rectangular coolant reservoir. The reservoir is constructed of plywood braced with studs and waterproofed on the inside with polyester resin and fiberglass tape. The reservoir is insulated with 10 centimeters of styrofoam on all sides, including the inner bottom and lid. The evaporator coils fit tightly against the bottom and sides of the reservoir, and the antifreeze coolant level is maintained just to the top of the coils, so that all coolant circulating through the reservoir must pass through the aluminum cooling fin openings, not around the coils. Antifreeze is continually recirculated through the coils at 400 liters per minute with a 2-horsepower centrifugal pump equipped with special cold-temperature seals. The antifreeze coolant is ethylene glycol and fresh water blended to a freezing point of −20°C. The refrigeration compressor thermostat is adjusted to keep the coolant temperature between −8° and −12°C.

[1]Reference to trade names does not imply endorsement by the National Marine Fisheries Service.

Teflon immersion coil heat exchangers, through which chilled coolant circulates, are mounted in 2,000-liter, cylindrical, insulated fiberglass seawater reservoirs. In the low-temperature (1°C) seawater reservoir, a 650-tube Teflon heat exchanger 6 meters long (Hettler et al.), is hung from nylon supports around the inside periphery of the cylinder. In the intermediate temperature (15°C) reservoir, a 650-tube Teflon heat exchanger, 2.5 meters long, is hung next to a 280-tube Teflon heat exchanger, 2.5 meters long, (for heating). Thermistor sensors and temperature controllers operate 1/3-horsepower centrifugal pumps for each reservoir to circulate antifreeze coolant through the heat exchangers to cool the surrounding seawater. Seawater in the reservoirs is circulated around the Teflon tubes with compressed air, which additionally brings the seawater to approximately 100 percent air saturation. The intermediate temperature seawater reservoir uses the same temperature controller to either cool or heat the seawater, depending on the ambient temperature. The heating system was previously described by Hettler et al.

The volume of seawater chilled depends on the incoming seawater temperature, the differential between the coolant temperature and the desired seawater temperature, the amount of slime fouling of the heat exchanger, and the ambient air temperature. The maximum capacity of our system, beyond which the unit cannot maintain the set temperature when this set temperature was 1°C, was measured to be 187 degree-liters per minute. For example, if the ambient seawater temperature was 25°C, approximately 8 liters per minute could be chilled to 1°C; with 5°C incoming water, approximately 47 liters per minute would be available. The heat exchangers require periodic cleaning to remove bacterial slime which clogs the spaces between the individual Teflon tubes and prevents efficient heat removal. At bimonthly intervals a weak sodium hypochlorite solution is circulated in the seawater reservoirs for several hours and then the tanks and heat exchangers are hosed with a strong stream of fresh water.

With the addition of the chiller unit, our seawater system now has low, medium, and high temperature water outlets at each tank or aquarium. By mixing water of two temperatures, one above and one below the desired temperature, we have available year-around a complete range of temperature controlled seawater for experiments on estuarine organisms.



$BF_{1,2}$ -BACK-FLUSH VALVE
BP -FILTER BY-PASS VALVE
$D_{1,2}$ -BACK-FLUSH DRAIN VALVE
CO -PUMP CUT OUT VALVE
CP -CENTRIFUGAL PUMP, 170 LITERS/MIN.

$F_{1,2}$ -FLOAT VALVE
$I_{1,2}$ -SEA WATER INLET VALVES
M -MANIFOLD BENEATH OYSTER SHELLS
$P_{1,2}$ -PARALLEL OPERATION VALVE
PS -FROM PRIMARY STORAGE RESERVOIRS

$R_{1,2}$ -PUMP RELIEF RETURN VALVE
$S_{1,2}$ -SERIES OPERATION VALVE
$T_{1,2}$ -FILTER TANKS, 3.14-m^2
TD -TO DRAIN
TS -TO TEMP./SALINITY CONTROL RESERVOIRS
X -BACK-FLUSH AIR OUTLETS
→ -DIRECTION OF FLOW

Figure 1.—Schematic of filter system. In paralled operation the following valves would be open: $I_{1,2}$, $F_{1,2}$, $R_{1,2}$, $P_{1,2}$, and CO. In series operation (finer filtration) with T_1 as the primary filter and T_2 as the secondary filter the following valves would be open: I_1, F_1, S_2, P_2, R_2, and CO. For back-flushing T_1 the following valves would be open: BF_1 and D_1. Inset shows a cross-sectional view of a filter.

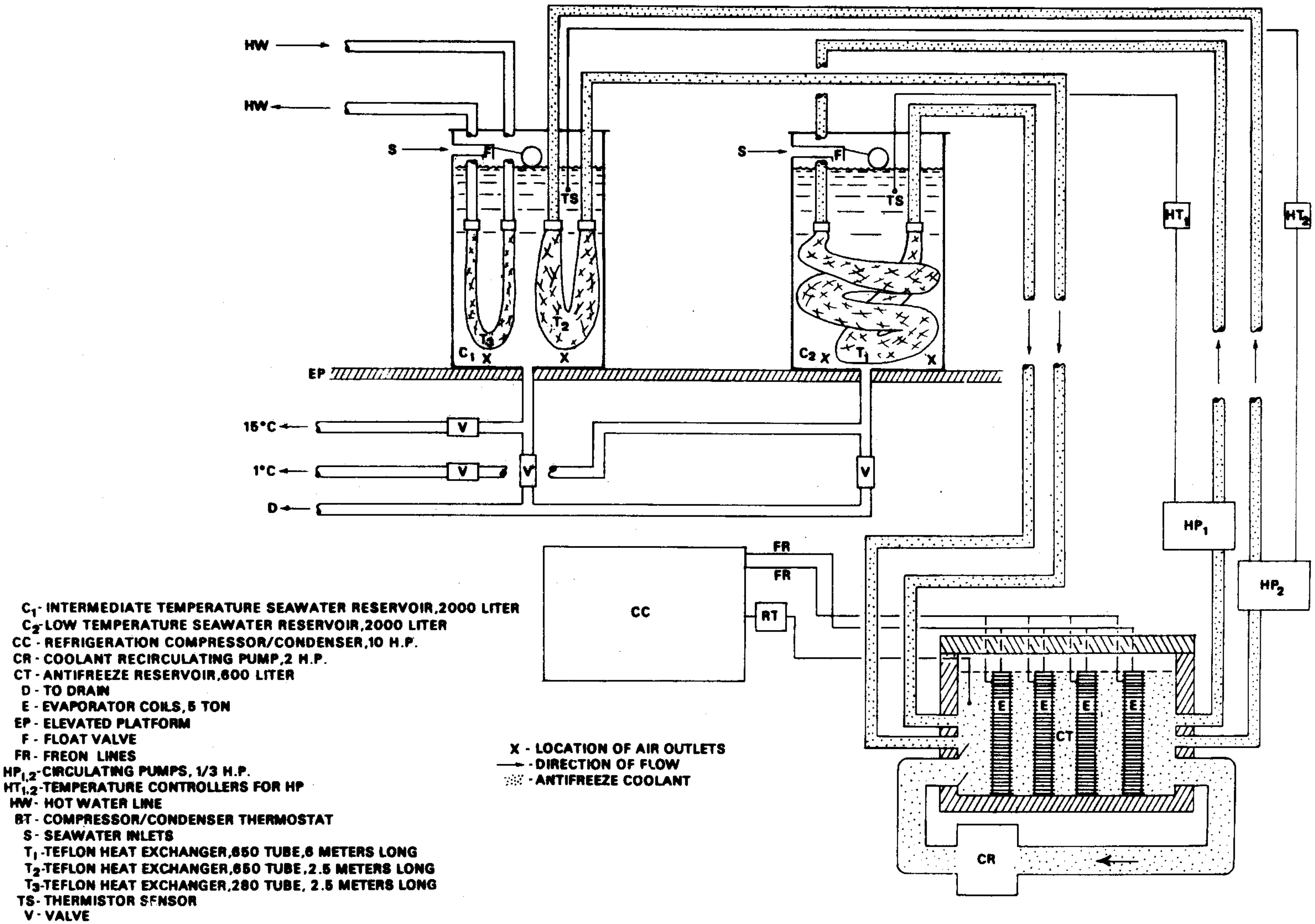


Figure 2.—Diagram of seawater chiller. The cooling cycle would operate in the following sequence for reservoir C_2: TS senses elevated temperature in C_2; HT_1 turns on pump HP_1; coolant from CT is then pumped through heat exchanger T_1; warmed coolant returns to CT where excess heat is removed by coils, E, and compressor/condenser CC; pump HP_1 stops when C_2 is at proper temperature.

List of components and approximate cost

Item (including labor)	Total cost
Filters:	
Filtertanks, 2,300-liter, 2-meter diameter, fiberglass (two)	$1,200
PVC pipe, valves, and fittings (total)	800
Pump, 1/3-hp nitrile rubber centrifugal (one)	160
Oyster shells, crushed, "pullet-size" (2.5 tons)	220
Chiller:	
Refrigeration compressor/condenser (one)	1,200
Air-conditioner evaporators, 5-ton (four)	1,200
Plywood—fiberglass refrigerant reservoir (one)	150
Teflon heat exchangers, 650-tube units (8.5 meters)	3,500
Pump, 2-hp coolant recirculating, cast iron (one)	400
Pumps, 1/3-hp heat exchanger, cast iron (two)	210
Temperature controllers and thermistors (two)	230
Ethylene glycol antifreeze (400 liters)	150
Seawater reservoirs, 2,000-liter fiberglass (two)	1,000
PVC pipe, valves, fittings, and insulation (total)	150

REFERENCE

HETTLER, WILLIAM F., JR., RICHARD W. LICHTENHELD, and HERBERT R. GORDY.
1971. Open seawater system with controlled temperature and salinity. Progressive Fish-Culturist, vol. 33, no. 1, p. 1–11.

Nalgene Poly-Paper as a Label Material

In an effort to determine its characteristics as a potential label material Nalgene Poly-Paper was tested in the following manner. Poly-Paper and four other types of paper commonly used for label stock were reduced to 1- by 3-centimeter slips and marked by 3H graphite pencil, Higgins and Pelikan india inks, Singer Flexowriter, and IBM typewriter. Representative sets of the marked papers were placed in 500-milliliter Erlenmeyer flasks each of which contained 200 milliliters of one of the following fluids: glacial acetic acid, ammonium hydroxide, Zenker's, Alconox in water, seawater, AFA, Chlorox, distilled water, xylene, embalming fluid, picric acid, Bouin's, FAA, formaldehyde, and ethyl alcohol 80 percent. The flasks were then stoppered and agitated on a culture flask shaker for 2 months at 25°C.

Evaluation of the labels for legibility and dimensional stability disclosed that in general Nalgene Poly-Paper was the only sample to survive the experiment essentially unchanged. The majority of papers was reduced to a slurry within 48 hours. It is interesting to note that only the data written with pencil or typewriter remained perfectly legible and then often only by impression. The results suggest that Poly-Paper is distinctly superior to conventional label papers.

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